MODULAR WALL SEGMENTS AND METHOD OF MAKING SUCH SEGMENTS

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RELATED APPLICATION

This application is a continuation of U.S. Patent Application Serial No. 10/032,455 filed January 2, 2002, now U.S. Patent No. 6,6XX,XXX.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to a modular wall segment construction, to methods of making such segments, and to uses of such segments in the construction of walls.

Construction methods currently in popular use in many locations and climates are typically slow and labor-intensive. In Israel, for example, most constructions of interior walls rely on methods substantially unchanged over many years. Interior walls built in Israel, as well as those built in many similar climates, are typically constructed of cinderblock or of cement-based blocks of other types (referred to collectively hereinbelow as "construction blocks"), built into a wall by masons on the construction site, then covered by hand with a mixture of cement and fine sand, and finally finished by paint or plaster. Openings for doors and windows are measured on site and built into the block-based construction by hand, and channels for electrical and plumbing conduits are typically chiseled by hand into the constructed wall.

The popular construction process here described is not only slow and labor intensive, but also requires a high degree of skill and workmanship. Any failure in the workmanship may result in unevenness in the wall surface, or inaccurate placement of planned fixtures.

Alternative methods for the construction of interior non-loadbearing walls involve the use of broad prefabricated sheets of walling material, such as sheetrock, wallboard, gypsum board, DENSEGLASS, sheetrock, concreteboard or plasterboard. Such materials, referred to collectively hereinbelow as "walling sheets", are often used together with a variety of insulating materials to produce interior walls. To construct a wall using walling sheets, a worker typically erects a metal or plastic frame at the desired location of the wall, and then attaches walling sheets to both sides of the frame, and, optionally, fills the space between the pair of walling sheets with insulating material.

Walls constructed of walling sheets are typically built more rapidly than those built of construction blocks, and have the advantage that the walling sheets themselves are smooth and typically present a fairly aesthetic and finished appearance, once attached to a frame. Therefore, building walls using walling sheets may be accomplished by workers having less professional skill than those required to erect a smooth, vertical, and well-finished wall using construction blocks. Both the greater rapidity of construction, and the lower skill requirements for the construction workers, are reflected in substantially lower construction costs for walls built of walling sheets in modular units. However, walls built using walling sheets are typically of lower quality than those built using construction blocks. In particular, walls built of walling sheets are typically less

strong and less solid than walls built of construction blocks, and their thermal and acoustic insulating qualities are inferior.

Thus, there is a widely recognized need for, and it would be highly advantageous to have, a construction material and method of construction which provide the relative rapidity, simplicity and reduced manpower costs of modular construction, as well as the smooth, aesthetic, and highly finished appearance of walls constructed with walling sheets, together with the high-quality, strength, solidity and good acoustic and thermal insulating properties, of walls constructed with construction blocks.

Under construction practices typically in use at construction sites in Israel and in many other locations, responsibility for implementing the detailed plans provided by architects and engineers for accurately measuring and accurately implementing the correct placement of openings for doors and windows, for communication and electrical conduits, and for pipes and other conduits, typically falls on the masons constructing the walls. The fact that primary responsibility for accurate placement of such features is in the hands of on-site masons or other construction workers building the walls further reinforces the need for highly skilled, and consequently relatively expensive, construction workers on the construction site.

Thus, there is further a widely recognized need for, and it would be highly advantageous to have, a construction material and a method of construction which enable the building of walls having openings and fixtures which are elegantly finished and accurately placed according to architects' and engineers' specifications, yet which do not require highly skilled personnel at the construction site.

Prior art methods for building walls further include the use of pre-fabricated modular wall segments each comprising a pair of walling sheets sandwiching between them an insulating material of some sort. Argal, Calcar, and various polyurethane-based compositions have been used as insulating material in this context. The modular wall segments thereby produced do allow relatively easy wall construction, yet they fail to provide the solidity and acoustic and thermal isolating properties comparable to those obtained with masonry walls built of construction blocks. Moreover, many such materials have been found to be flammable, or to emit poisonous gasses into the surrounding environment when heated. For this and other reasons, available pre-fabricated modular wall segments comprising walling sheets surrounding an insulating material do not meet the minimum acceptable standards required under the building codes in force in Israel and in various other localities.

Thus there is further a widely recognized need for, and it would be highly advantageous to have, a construction material and a method of construction providing the advantages of rapidity and simplicity of modular construction and the solidity and insulating qualities of construction-block construction, while utilizing material components which are not flammable and which cause no harmful emissions to the environment when heated, and which are already recognized as acceptable building materials according to common practice and according to the legal requirements of the building codes in force in many localities.

In localities which suffer periodic earthquakes, the dangers and disadvantages of falling masonry construction blocks are well known. Falling masonry construction blocks comprising the walls of a building may be responsible for damage to property and injury

and death to people, even in cases where the well-constructed load-bearing skeleton of the building (e.g., the reinforced concrete sections) survive an earthquake relatively intact.

Thus there is further a widely recognized need for, and it would be highly advantageous to have, a construction material and a method of construction which minimizes the danger of falling walls and wall components during earthquakes.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a modular wall segment for constructing a wall, comprising: (a) a first walling sheet of a selected two-dimensional shape and size; (b) a second walling sheet of the selected two-dimensional shape and size; and (c) a plurality of aerated concrete blocks contiguously located in a plurality of rows and columns between said first and second walling sheets to form a volume of consistent thickness of the selected two-dimensional shape and size; the plurality of aerated concrete blocks being bonded on their opposite faces to the first and second walling sheets.

According to some described preferred embodiments, the aerated concrete blocks are contiguously placed in direct contact with each other and are secured together within the modular wall segment solely by the external layers. Another embodiment is described wherein the aerated concrete blocks include a quantity of a bonding material between them to augment their securement together within the modular wall segment by the external layers.

According to further features in the described preferred embodiments, the modular wall segment is formed on at least one end face with a slot for receiving a

fastening element to secure the modular wall segment to other modular wall segments. Various embodiments described below illustrate various types of configurations of slots, and of fastening elements to be received in such slots, for utilizing the segments in a modular manner to construct a wall or a juncture with a floor or ceiling.

The present invention thus addresses the shortcomings of the presently known configurations by providing a construction material and a method of construction which enable low-cost wall construction by utilizing the rapidity and simplicity of modular wall construction techniques, yet which produce high-quality, strong and solid walls whose acoustic and thermal insulating properties are comparable to those found in walls built using constructions blocks.

The present invention further addresses the shortcomings of the presently known configurations by providing a construction material and a method of construction which enable building walls with highly accurate placement of openings and fixtures, yet which do not require highly skilled personnel at the construction site.

The present invention still further addresses the shortcomings of the presently known configurations by providing a construction material and a method of construction providing the rapidity and simplicity of modular wall construction and the solidity and insulating qualities of construction-block construction, while enabling the utilization of materials which cause no harmful emissions to the environment and which are widely recognized and accepted as building materials both according to common practice and according to the building codes in force in a wide variety of locations.

The present invention still further addresses the shortcomings of the presently known configurations by providing a construction material and a method of construction which minimize danger of falling walls and wall components during an earthquake.

Further features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

Fig. 1 is a simplified cross-section of a modular wall segment according to an embodiment of the present invention;

Fig. 2 is a simplified isometric illustration of a modular wall segment according to another embodiment of the present invention;

Fig. 3 is a simplified flow chart showing a preferred method for constructing a modular wall segment according to an embodiment of the present invention;

Figs. 4a and 4b are simplified cross-sectional views of preferred methods for joining modular wall segments one to another to make a wall, according to an embodiment of the present invention;

Figs. 5a and 5b are simplified isometric views, and Fig. 5c is a cross-sectional view of further configurations for joining modular wall segments longitudinally, according to an embodiment of the present invention;

Fig. 6 is a simplified cross-sectional view of a configuration for joining a modular wall segment to a ceiling or to a floor, according to an embodiment of the present invention;

Figs. 7a and 7b are simplified isometric views of a configuration for joining a modular wall segment to a floor which is not horizontal, according to an embodiment of the present invention;

Fig. 8 is a simplified isometric view of further configurations for joining several modular wall segments one to another to make a wall, according to an embodiment of the present invention;

Fig. 9 is a simplified isometric view of a configuration for joining modular wall segments perpendicularly, according to an embodiment of the present invention;

Fig. 10 is a simplified isometric view of a configuration for joining modular wall segments in parallel, according to an embodiment of the present invention;

Fig. 11 is a simplified isometric view of a configuration for joining a modular wall segment to an exterior wall, according to an embodiment of the present invention;

Fig. 12 is a simplified isometric view of a configuration of walls composed of modular wall segments and including pre-planned small and large openings, according to an embodiment of the present invention; and

Fig. 13 is a simplified cross-sectional view of modular walls segments in a configuration reducing danger from earthquakes, according to an embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention involves a modular wall segment comprising an inner layer of aerated concrete blocks glued between two outer layers, methods for constructing same, and uses thereof. Specifically, the present invention can be used to construct walls which combine the advantages of modular construction, easy and rapid installation, and aesthetic appearance, with the solidity and thermal and acoustic isolating qualities of construction-blocks.

To enhance clarity of the following descriptions, the following phrases will first be defined:

The phrase " aerated concrete block" is used herein to refer to a block suitable for use as a building material, containing cement, sand, and other materials, and having a highly porous internal structure or a cellularized internal structure. Such blocks may be produced, for example, by a process of mixing cement, sand, lime, cement, and a foaming agent with water and pouring into a mold. The foaming agent causes tiny bubbles to develop within the cement mixture. The bubbles remain interspersed within the cement mixture. When the mixture hardens, these tiny bubbles are permanently fixed within the block structure, resulting in a cement-based construction block having an internal cellular

structure which includes multiple small spaces formed by the bubbles created by the foaming process. The block thereby formed is strong and solid and is a good thermal and acoustic insulator, yet is significantly less dense than would be a block formed of a comparable mixture of cement, sand, lime and water without the use of a foaming agent. In a typical fabrication process, the mixture is poured into a form, foams up to about double its volume, is kept moist, and is allowed to set for about 90 minutes, after which it is hard enough so that it can be moved, or cut to desired dimensions.

Construction blocks marketed under the trade name YTONG and construction blocks marketed under the trade name ESHKOLIT are examples of aerated concrete blocks. It is noted that it is the cellularized or highly porous character of the blocks, and their relatively low density when compared to standard cement-based blocks, which are their defining characteristics. Aerated concrete blocks may be produced by the foaming process described hereinabove, or by any other process.

The phrase "walling sheets" is used herein to refer to any member of the general class of objects having a form which combines a relatively thin dimension, usually between several millimeters and several centimeters and most typically about one or two centimeters in thickness, with much larger width and height dimensions, typically from tens to several hundreds of centimeters in width and height, whose physical characteristics make them appropriate for use as partitioning elements in walls. Walling sheets typically have a generally smooth surface, aesthetically suitable for use in walls. Wood, for example plywood, wood composition boards, sheetrock, Gypsum board, cement-board, plasterboard, wallboard, and DENSEGLASS are examples of "walling sheets". It is noted that the expression "walling sheets" as used herein is not intended to

be limited to the specific examples here mentioned. Rather, the expression "walling sheets" is intended to refer to any objects of size, shape, and physical characteristics similar to those of plywood, sheetrock, gypsum board, cement-board, plasterboard, wallboard and DENSEGLASS, making them appropriate for use as part of a wall structure.

The principles of the construction and use of wall modules according to the present invention may be better understood with reference to the drawings and accompanying descriptions.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

Referring now to the drawings, Fig. 1 is a simplified cross-section of a modular wall segment according to an embodiment of the present invention.

A modular wall segment **101** comprises two external layers, individually designated as first external layer **105** and second external layer **107**, and an internal layer **111**.

Each external layer **105**, **107** is a walling sheet as defined hereinabove. Commercially available produces such as plywood, sheetrock, wallboard, plaster-board, cement-board, or DENSEGLASS may be used. These commercially available produces are, however, mentioned as illustrative examples only, and are not intended to limit the

scope of the invention. Any object of similar shape and physical characteristics, whether commercially available or specifically prepared for the purpose, may be utilized as walling sheets and incorporated in modular wall segment **101** as external layers **105, 107**.

Internal layer **111** comprises a plurality of aerated concrete blocks **113** located in a plurality of rows and columns between the walling sheets 105, 107, as more particularly seen in Figs. 2, 4a and 4b. Blocks **113** are shown as if slightly separated in Fig. 1, for clarity of the figure, but in practice blocks **113** are preferably contiguous one to another.

A first glue layer **116** between internal layer **111** and external layer **105**, and a second glue layer **118** between internal layer **111** and external layer **107** serves to hold these layers of modular wall segment **101** together as a unit.

A slot **114** may be provided in exposed surfaces of certain blocks **113** at the end faces of the respective segment to facilitate joining the modular wall segment **101** to floors, ceilings, and to other modular wall segments. In the construction illustrated in Fig. 1, slot **114** extends transversely through the block **113** at the respective end face of the segment.

Reference is now made to Fig. 2, which is a simplified isometric illustration of a modular wall segment according to an embodiment of the present invention. Fig. 2 presents a modular wall segment **101** similar in structure and identical in purpose to modular wall segment **101** shown in Fig. 1. As an aid to understanding, the numbered features of Fig. 1 are reproduced in Fig. 2 in isometric perspective. Slot **114'** in Fig. 2 is presented as a wide slot, whereas in Fig. 1 slot **114** is narrow. Slot **114** is formed in the end faces of the line of aerated concrete blocks at the respective end of the modular wall segment and extends parallel to the walling sheets 105 and 107. Slot **114'** in Fig. 2 is

defined by having the ends of the two walling sheets, **105, 107**, project past the end face of the aerated concrete block **113** at the respective end of the segment, and a U-shaped channel member **114''** is preferably introduced into that slot for reinforcement purposes. Both wide and narrow configurations of the slot **114** may be used for joining modular wall segment **101** to floors, ceilings and other modular wall segments. The relatively narrow slot **114** presented in Fig. 1 is a presently preferred configuration.

Reference is now made to Fig. 3, which is a simplified flow chart presenting a preferred method for constructing modular wall segment **101**, according to any embodiment of the present invention.

A first walling sheet **104** substantially formed in a selected two-dimensional shape and size is used as a basis for construction. The selected two-dimensional shape is typically rectangular, but any selected shape, and any convenient size, may be used.

At step **121** a first glue layer **116** consisting of a polyurethane-based glue is placed between a first walling sheet used as a first external layer **105** and a plurality of aerated concrete blocks **113** which constitute internal layer **111**. KLEIBERIT glue supplied by BECKER GMBH of Germany is a preferred glue for this purpose. Glue density of up to 375 gm per square meter, for each glue layer **116**, is preferred.

A convenient way to place first glue layer **116** between external layer **105** and blocks **113** is to lay a first walling sheet on an assembly table, spread glue on the sheet, and then place aerated concrete blocks **113** on the glue-coated walling sheet. Blocks **113** are placed contiguously, in contiguous parallel rows, so that they together constitute a volume of constant thickness approximating the size and shape of the walling sheet. Blocks **113** are placed in rows in the classical staggered relationship. Neither glue nor any other binding

material is required between contiguous blocks **113**, as blocks **113** are held in place by glue layer **116** between blocks **113** and the walling sheet of external layer **105**.

At step **123**, a second glue layer **118** is placed between aerated concrete blocks **113** and a second walling sheet to serve as the second external layer **107**. The shape and size of the second walling sheet preferably conforms to the two-dimensional shape and size of the first walling sheet defining the first external layer **105**. The second glue layer **118** can conveniently be applied by coating the exposed (upper) side of blocks **113** with glue, and then placing the second walling sheet over the glue-coated blocks **113**. At the conclusion of step **123**, first external layer **105**, internal layer **111**, and second external layer **107** are placed relative to each other in the configuration shown as modular wall segment **101** in Figs. 1 and 2 before the glue layers **116** and **118** intended to bind them together have solidified.

In step **125** pressure is applied to the construction in such a manner as to force both external layer **105** and external layer **107** to be pressed strongly into close contact with blocks **113** constituting inner layer **111**, and to be held in close contact until glue layers **116** and **118** become set. In a preferred mode of operation pressure is applied by transferring the constructed layers from the assembly table to a pressure table while preserving the layers' spatial relationships, and then using the pressure table to apply pressure vertical pressure which forces layers **105**, **111** and **107** to remain strongly pressed together while the glue dries. In a preferred method, a pressure of approximately 40 atmospheres per square centimeter is applied for approximately 40 minutes. After 40 minutes segment **101** may be moved to a storage area. In optional step **127**, glue layers **116** and **118** are preferably left to cure for an additional day prior to use of the segment.

In the method illustrated in Fig. 3, the blocks are placed in direct contact with each other and are secured together with the modular wall segment solely by the external layers bonded to the opposite faces of the blocks. It may be desirable in some cases, however, to also include a quantity of a bonding material, such as cement, between the contacting faces of the blocks to augment their securement together within the modular wall segment by the external layers.

In optional step **129**, a prepared segment **101** may be sawed to a desired size and shape, slots **114** may be cut, openings (e.g., for doors and windows) may be cut, channels (e.g., for electrical conduits) may be drilled. Slits and other configurations for joining one module to another, as described hereinbelow with reference to Fig. 4, may be prepared at this time.

The process described in Fig. 3 produces a modular wall segment **101** with desired characteristics. Segment **101** is strong, provides good thermal and acoustic isolation, yet is lighter and more easily worked than a wall of comparable shape and size constructed of cinderblock or construction blocks of other sorts. Segment **101** has smooth and aesthetically pleasing external surfaces with a finished appearance, ready for painting. Segment **101** may be cut to a desired width and shape using a saw. Walls constructed of modular wall segments **101** may be used for internal (non-load-bearing) walls. Segments **101** can also be used as an aesthetic surfacing material (inside or outside) for other types of walls, such as cast concrete exterior walls of a building. Segments **101** can be combined with insulating materials to constitute exterior walls of a building, as will be shown hereinbelow, and may be used to construct fences and similar structures.

In a preferred embodiment using YTONG blocks as aerated concrete blocks **113**, a segment a square meter in area and seven centimeters thick weight approximately 42 kg, and meets the Israeli construction standards for acoustic insulation, for thermal insulation, and the Israeli mechanical strength standard #268. The wall segments so constructed are also fairly impervious to water but in wet environments it is recommended to spread a material impermeable to water on the module's surface before installation. HYDROGUM is an example of an appropriate material for this purpose. In a preferred embodiment, a recommended standard size for a modular wall segment is 60 cm in width and 260 cm in height, but modular wall segments can alternatively be constructed in various other shapes and dimensions.

Reference is now made to Figs. 4a and 4b which present simplified cross-sectional views of two preferred methods for joining modular wall segments **101** into a continuous surface, thereby constructing a modularized wall, according to embodiments of the present invention. Figs. 4a and 4b present partial views of a wall 131a, 131b consisting of two modular wall segments **133a, 133b** and **135a, 135b,** joined together at juncture **137a, 137b**.

In Fig. 4A, glue is used to join a flat end of segment **133a** to a flat end of segment **135a.** Additionally, a slot **139** in segment **135a** is so positioned that it faces a corresponding slot **141** in segment **133a** when the two segments are to be joined. A connecting plate **143,** which is preferably a metal plate, is coated with glue and positioned so as to substantially fill both slot **139** and slot **141**. Glue thus fixes connecting plate **143** both to slot **139** of segment **133a** and to slot **141** of segment **135a**, and consequently serves to reinforce the joining of the two segments.

Fig. 4b shows an alternative method for joining the two segments 133b, 135b. In Fig. 4b an end of segment **135b** is shaped as a rib **155**, whereas an end of segment **133** is shaped with a slot or recess **161**, the rib **155** being of a size and position to slide snugly into the recess **161** during construction of wall **131**, where it is glued in place. Recess **161** is preferably dimensioned as described above with respect to slot **114** as shown in Fig. 1, or as described above with respect to slot **114'** as shown in Fig. 2.

Fig. 4b also illustrates the alternative construction wherein each modular wall segment **101** is formed with a rib **155** at one end face, and with a slot **161** at the opposite end face, to enable a plurality of such segments to be assembled together in modular fashion.

Reference is now made to Figs. 5a – 5c, which present simplified isometric and cross-sectional views of additional configurations for joining modular wall segments longitudinally, according to embodiments of the present invention. The joining configurations illustrated are particularly appropriate for the joining of modular wall segments for external use, for example for external walls and for fences. The joining configurations illustrated are appropriate for horizontal configurations, joining a plurality of modular segments to make a long wall, and are also appropriate for vertical configurations, joining a plurality of segments to make a high wall.

In Fig. 5a, modular wall segment **231** is joined to modular wall segment **233** by use of an I-shaped joining element **235**. Segments **231** and **233** are constructed with flat ends shaped to fit into I-shaped joining element **235**, where they can be glued or preferably screwed or bolted into place. I-shaped joining element **235** is preferably of concrete or metallic composition, and consequently may be a load-bearing element.

Fig. 5b presents an isometric view of a cruciform joining element **237**, preferably of metallic composition, which may also be used to join two modular wall segments longitudinally. The position in which cruciform joining element **237** may be placed is indicated in isometric presentation in Fig. 5a, and in cross-sectional presentation in Fig. 5c. In both Fig. 5a and Fig. 5c, cruciform joining element **237** is shown joining modular wall segments **233** and **234**. Use of cruciform joining element **237** requires that slots be prepared in the ends of segments **233** and **234**, similar to slots **141** and **139** of Fig. 4a.

Reference is now made to Fig. 6, which presents a simplified cross-sectional view of a configuration for joining a modular wall segment to a ceiling or to a floor or to both a ceiling and a floor, according to an embodiment of the present invention. For connecting to a ceiling **178**, modular wall segment **101** is prepared at its top end with a flat end face **173**, in which a longitudinal slot **175** is prepared, running the length of end face **173**. A T-shaped connecting form **177**, preferably of metal, is screwed, bolted, glued or otherwise connected to ceiling **178** and is used to position modular wall segment **101** with respect to ceiling **178**. T-shaped connecting form **177**, shown in Fig. 6 as being more narrow than the thickness of modular wall segment **101**, may alternatively be of width equal to the thickness of segment **101**, or yet wider.

The configuration presented in Fig. 6 also serves for connecting modular wall segment **101** to a floor. Segment **101** is prepared also at its bottom end with flat face **174** in which a longitudinal slot **175** is prepared, running the length of bottom surface **174**. A T-shaped connecting form **177**, preferably of metal, is screwed, bolted, glued or

otherwise connected to a floor **179** and is used to position modular wall segment **101** with respect to floor **179**.

In typical use, an interior wall **131** is erected to partition an interior space by first attaching T-shaped connecting forms **177** to the floor and ceiling along most of the length along which it is desired to erect the wall **131**, yet leaving a small section of the intended wall length with at least one form **177** (ceiling or floor) unattached, to create a staging area. Modular wall segments **101**, constructed to be of an appropriate height and having longitudinal slots **175** along the top and bottom, are simply moved into the staging area, slotted onto T-shaped connecting forms **177**, and slid along those forms, one segment **101** after another, until the space to be partitioned has been nearly filled and most of the wall **131** erected. A final segment, completing the wall **131**, is erected in the staging area by slotting a final section of T-shaped connecting form **177** into a segment **101** before attaching form **177** to the ceiling or floor. Final segment **101** is erected in place, and final section form **177** is then attached to wall or floor as appropriate, completing construction of wall **131**.

In a recommended mode of operation, a commercially available sealing agent, impervious to water, is spread on top surface **173**, bottom surface **174**, in slits **175**, and on T-shaped connecting forms **177** before installing modular wall segments **101** on T-shaped connecting forms **177**.

The configuration presented in Fig. 6 also serves for connecting modular wall segment **101** to a wall **172**. In this usage T-shaped connecting form **177** is screwed, bolted, glued or otherwise connected to a wall **172** of any sort, such as, for example, a reinforced concrete exterior wall of a building. Form **177** can be connected to a flat end

face of wall **172** to create a linear horizontal or a vertical extension of wall **172.** Alternatively, form **177** can be connected to a side face of wall **172,** to join wall **172** and segment **101** in a perpendicular or near-perpendicular configuration. Segment **101** is prepared with longitudinal slot **175** running the length of a flat end face, and an exposed portion of form **177**, extending outward from wall **172** to which it is attached, is fitted into slot **175** to form a joint, which joint is then preferably reinforced using glue, screws, bolts, or similar materials.

Similarly, the configuration presented in Fig. 6 may also serve for connecting modular wall segment **101** to a second, like modular wall segment. In this usage, element **172** shown in Fig. 6 would also be a modular wall segment of the same construction as segment **101**, and the T-shaped connecting form **177** would be screwed, bolted, glued or otherwise connected to wall segment **172**, either to a flat end face thereof to create a linear horizontal or a vertical extension of wall segment **101**, or to a side face thereof to join it to wall segment **101** in a perpendicular or near-perpendicular configuration. Segment **101** is prepared with longitudinal slot **175** running the length of a flat end face, and an exposed portion of form **177**, extending outward from the other wall segment **172** to which it is attached, is fitted into slot **175** to form a joint, which joint is then preferably reinforced using glue, screws, bolts, or similar materials.

Reference is now made to Figs. 7a and 7b, which present simplified isometric views of a configuration for joining modular wall segment **101** to a floor that is not horizontal, according to an embodiment of the present invention. In general, it is desirable to provide a horizontal floor surface at the point of installation of modular wall segments **101**. This is preferably accomplished by casting a horizontal concrete strip,

preferably about 7 cm in height and 4 cm thick, on which T-shaped connecting form **177** of Fig. 6, or other connecting forms or arrangements, or modular wall segment **101** itself, may be placed.

A further recommended mode of operation is presented in two phases in Figs. 7a and 7b. In a first phase of operation shown at Fig. 7a, modular wall segment **101** is propped temporarily in a horizontal position using shims **146**. Small sections of walling board, for example, may be used for this purpose. In a second phase of operation shown at Fig. 7b, a form is constructed around the base of modular wall segment **101**, and a concrete strip **147** is cast under segment **101**.

Reference is now made to Fig. 8, which presents a simplified isometric view of several additional configurations for joining several modular wall segments one to another to make a wall, according to an embodiment of the present invention.

In Fig. 8, elements **201**, **203**, and **205** are each modular wall segments (corresponding to segment **101** described earlier) here shown as joined one to another to make a wall **206**. In Fig. 8 a rectangular connecting form **191a,** illustrating an alternate construction serving the same function as that of T-shaped connecting form **177** in Fig. 6, is used to connect segment **201** to a ceiling. Holes **207** may be used to screw or bolt connecting form **191a** to a ceiling. Similarly, a second connecting form, marked **191b** is shown as the means by which segments **203** and **205** are connected to a floor.

A third connecting form **191c** serves a different purpose. Connecting form **191c** fits into a slot **114** at the bottom of segment **201** and into a slot **114b** at the tops of segments **203** and **205**, and serves to join segment **201** vertically to segments **203** and **205**. This vertical joining method is useful when it is desired to build a wall taller than the

maximum height of available individual wall segments **101**. In an alternate construction, T-shaped connecting form **177**, shown in Fig. 6, may be used in place of connecting form **191c** to join segment **201** vertically to segments **203** and **205**. In this case, T-shaped connecting form **177** in Fig. 6 is glued or otherwise attached to the bottom of segment **201** and fits into slot **114b**, or is attached to the tops of segments **203** and **205** and fits into slot **114a**.

Reference is now made to Fig. 9, which presents a simplified isometric view of a configuration for joining modular wall segments perpendicularly, according to an embodiment of the present invention. A connecting form **221**, screwed, glued, bolted or otherwise attached to a side of a first modular wall segment **223**, fits into a slot **114** in the end of a second modular wall segment **225.** Connecting form **221** is then screwed, glued, bolted or otherwise attached in slot **114**, thereby joining segment **223** to segment **225** perpendicularly.

Reference is now made to Fig. 10, which presents a simplified isometric view of a configuration for joining modular wall segments in parallel to produce a composite modular wall segment for constructing a wall and constituted of two of the above-described segments of the same dimensions joined together at the planar outer faces of their respective walling sheets. In such a composite configuration, insulating material **245**, such as thermal insulation or acoustic insulation, is placed between, and may be attached (e.g. by gluing) to, both first modular wall segment **241** on a first side of said insulating material, and second modular wall segment **243** on a second side of said insulating material. This sandwich configuration thereby constructed is particularly recommended for use as an outside wall.

Reference is now made to Fig. 11, which presents a simplified isometric view of a configuration for joining a modular wall segment to an exterior wall, according to an embodiment of the present invention.

Exterior wall **247** is typically not a modular wall segment **101**, but rather is constructed by other means. Exterior wall **247** might be, for example, a poured concrete wall. Exterior wall **247** may be a load-bearing wall.

According to a preferred embodiment, exterior wall **247** is prepared to include bolts or other fasteners appropriately placed for use for connecting an interior wall. In a preferred mode of operation, waterproofing material is applied to exterior wall **247** if appropriate. Insulating material **246** of appropriate thickness is placed on the inner surface of exterior wall **247**. Water pipes, drain pipes, conduits for electricity, for electronic communications, and optionally for other installations are installed at this time. Modular wall segment **241** is then connected to exterior wall **247** by means of bolts or other connectors provided for the purpose.

Reference is now made to Fig. 12, which presents a simplified isometric view of a configuration of walls composed of modular wall segments (e.g., **101** described earlier) and including pre-planned small and large openings, according to an embodiment of the present invention.

In a recommended mode of use, when constructing walls of a building or part of a building utilizing embodiments of the present invention, detailed plans for the interior construction, based on architects drawings and engineers specifications, are taken into account in the planning, design, and construction of appropriately sized and shaped modular wall segments. Users of the modular wall segments (typically, the construction

crew) provide makers of the wall segments (typically, a commercial supplier or factory) with detailed specifications of the sizes and placements of the walls and the desired positions of openings such as windows and doors, and desired smaller penetrations in the walls for elements such as channels for electrical conduits and openings such a for electrical outlets. The makers of the wall segments can then design segments of accurately appropriate sizes, and use the manufacturing facilities of their workshop or factory to cut or drill appropriate openings in the constructed modules, which process can be accomplished with ease and accuracy in the factory or industrial setting.

In Fig. 12, modular wall segment **253,** for example, comprises a prepared channel **257** for electrical wiring and a prepared opening **259** for an electrical connection. Segments **251** and **253** are shown in Fig. 12 to have been shaped or cut so as to provide an opening **255** appropriate for a door. Optionally, a wooden door frame base **261** is provided glued to, or embedded in, segments **251** and **253**. Wooden door frame base **261** is of great utility in providing for elegantly finished doors within the constructed walls, in that door frame base **261** can be accurately measured and affixed to the segments during production of the segments, thus requiring no cutting or shaping of the segments at the construction site. An aesthetically pleasing external door frame element (not shown) can easily be affixed to door frame base **261** at the construction site, for example using glue and a staple gun.

In a preferred mode of operation, the makers of the module carefully number and mark each module, identifying its place in the installation plan. The construction crew at the building site can prepare the appropriate connecting forms attached to floors, ceilings, and exterior walls according to the same plan. On delivery of the prepared modular wall

segments to the building site, the building crew can easily and rapidly erect the walls on the prepared connecting forms, and all openings and penetrations designed by the building's architects and engineers will be accurately in place and present a finished appearance. If needed, the builders may apply small amounts of filler to cover any cracks caused by the installation process, and the walls are finished and ready for a coat of paint.

Should it be desired to strengthen modular segment **101** beyond the strength required for normal construction and beyond the strength requirements of standard building codes, metallic elements, such as metal reinforcement wires, nettings or cages, may be added to the sandwich construction during the construction phase of the modular segments described with reference to Fig. 3, thereby further strengthening the modular wall segments. It is, however, generally an advantage of the described modular wall segment (e.g., **101**) that such strengthening elements are usually unnecessary, and the fact that the segments typically contain no metallic elements adds convenience, in that no care need be take to locate and to avoid internal metallic elements when cutting or drilling the segments.

Reference is now made to Fig. 13, which is a simplified isometric view of a configuration for reducing danger from earthquakes, according to an embodiment of the present invention. Experience has shown that during seismic disturbances, some or all of the load-bearing structures of a building may survive intact or nearly intact, yet people are endangered and property destroyed because of falling masonry from a building's interior walls. Fig. 13 presents a configuration of modular wall segments **301a, 301b** joined to form a wall in a manner which enhances security of the wall in the face of seismic disturbances. Modular wall segments **301a** and **301b** have been prepared with interior channels **381** drilled or otherwise constructed running lengthwise of the length of

the modular segments. In Fig. 13, three such channels are shown. Each channel **381** is for accommodating a cable **385**, which is made to pass through channel **381** in segment **301a**, and also through channel **381** in segment **301b**, thereby linking segments **301a** and **301b** with a strong metallic cable. The ends of cable **385** are firmly attached to load-bearing structures of a building, such as a steel framework, or a steel-reinforced poured concrete element. In the event of an earthquake or other major trauma to the building structure, if the load-bearing structures to which cables **385** are anchored survive the disturbance, modular wall segments **301a, 301b** are held together, and may largely be prevented from falling and doing damage, by cables **385.** The configuration shown in Fig. 13 substantially reduces risk that segments **301a, 301b** will fall from place and endanger lives and property during a seismic disturbance.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.